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# TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

| Attorney's Docket No. | U.S. Application No. (if known, see 37 CFR 1.5) |
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| 2576-113 | Not Yet Assigned 09/914218 |

| INTERNATIONAL APPLICATION NO. | INTERNATIONAL FILING DATE | PRIORITY DATE CLAIMED |
|---|---|---|
| PCT/JP00/00090 | January 11, 2000 | |

**TITLE OF INVENTION**
PORTABLE RADIO EQUIPMENT



**APPLICANT(S) FOR DO/EO/US**
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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [ ] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [X] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has **NOT** expired.
   d. [X] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**ITEMS 11. TO 16. below concern other document(s) or information included:**

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [X] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A **FIRST** preliminary amendment.
    [ ] A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information: Courtesy copy of International Application PCT/JP00/00090 w/attached International Search Report in Japanese and English; 8sheets of drawings; 11 cited references

JC05 Rec'd PCT/PTO 24 AUG 2001

| U.S. APPLICATION NO. (If known, see 37 CFR 1.5) | INTERNATIONAL APPLICATION NO. | ATTORNEY DOCKET NO. |
|---|---|---|
| Not Yet Assigned 09/914218 | PCT/JP00/00090 | 2576-113 |

| 17. [X] The following fees are submitted: | | CALCULATIONS | PTO USE ONLY |
|---|---|---|---|
| **Basic National Fee (37 CFR 1.492)(a)(1)-(5):** | | | |
| Search Report has been prepared by the EPO or JPO | $ 860.00 | | |
| International preliminary examination fee paid to USPTO (37 CFR 1.482) | $ 690.00 | | |
| No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) | $ 710.00 | | |
| Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO | $ 1,000.00 | | |
| International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) | $ 100.00 | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | | $ 860.00 | |
| Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | | $ | |

| Claims | Number Filed | Number Extra | Rate | | |
|---|---|---|---|---|---|
| Total Claims | 9 -20 = | 0 | X $18.00 | $ | |
| Independent Claims | 1 - 3 = | 0 | X $80.00 | $ | |
| Multiple dependent claim(s) (if applicable) | | | + $270.00 | $ | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $ 860.00 | |
| Reduction by 1/2 for filing by small entity, if applicable. Applicant(s) hereby claim small entity. | | | | $ | |
| **SUBTOTAL =** | | | | $ 860.00 | |
| Processing fee of $130.00 for furnishing the English translation later [ ] 20 [ ] 30 than months from the earliest claimed priority date (37 CFR 1.492(f)). + | | | | $ | |
| **TOTAL NATIONAL FEE =** | | | | $ 860.00 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property + | | | | $ 40.00 | |
| **TOTAL FEES ENCLOSED =** | | | | $ 900.00 | |
| | | | | Amount to be refunded | $ |
| | | | | charged | $ |

a. [X] Two checks totaling $900.00 to cover the above fees are enclosed.

b. [ ] Please charge my Deposit Account No. 02-2135 in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

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d. [ ] Payment by credit card. (Form PTO-2038 enclosed.)

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

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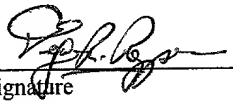


Signature

George R. Repper
Name

31,414
Registration Number

# SPECIFICATION

## Portable Radio Equipment

### Technical Field

The present invention relates to portable radio equipment, and more particularly, to portable radio equipment communicating with a base station that uses an antenna having one main plane of polarization.

### Background Art

As transmitting/receiving antennas for use in portable radio equipment, a whip antenna attached to a cabinet in the longitudinal direction and a helical antenna are known. Of the antennas for portable radio equipment commercially available at present in Japan, the one of a whip and helical type is often utilized, which operates as a whip antenna when pulled out, and a helical antenna provided at the end of the whip antenna via an insulator comes to work when retracted. An inverted F antenna or the like is built in the cabinet as an antenna for reception diversity.

Generally, one of the causes that would degrade characteristics of an antenna is antenna efficiency, which is determined from an effective radiation area according to the physical size and structure of the antenna. Others include loss due to impedance mismatch with a radio unit and loss due to nonconformity of directivity and plane of polarization with an antenna as a counterpart in communication.

An antenna on the mobile terminal side of the mobile communication like the portable radio equipment is placed or held in different environments as the terminal moves, so that directivity and plane of polarization thereof change constantly. In addition, since such equipment is often employed near a human body, it tends to be affected by the human body nearby.

Fig. 9 shows exemplary details of loss of gain averaged through the horizontal plane during a call of portable radio equipment provided with a

whip antenna attached to the metal cabinet. As seen from Fig. 9, compared to the loss due to the influence of the adjacent human body or due to mismatch, the loss due to the difference of polarization is considerably large.

An antenna at the base station that communicates with the portable radio equipment has, as its main polarization, vertical polarization with respect to the land surface. Although the waves transmitted from the transmitting/receiving antenna of the base station repeat reflection and diffraction due to buildings and other structures until they reach the receiving antenna of the portable radio equipment, it is known that the main polarization of the waves transmitted from the base station to the portable radio equipment is generally the vertical polarization. Regarding the reception characteristic of the transmitting/receiving antenna at the base station, it is obvious, from the reversibility of the transmission/reception characteristics of an antenna, that the antenna gain will increase as the vertically polarized wave components in the waves coming from the portable radio equipment are more dominant.

The whip antennas and others placed on the portable radio equipment have various kinds of radiation patterns according to electrical lengths of the antenna elements and sizes of the cabinets. However, it is known that, when the portable radio equipment is placed in an upright position, the main polarization becomes vertical to the land surface.

Thus, when portable radio equipment is being used for communication (often tilted at about 60 degrees from a zenithal direction) or placed horizontally on a desk or the like, the main polarization of the antenna formed in the portable radio equipment comes to considerably deviate from the main polarization of the antenna at the base station that is vertical to the land surface. This causes degradation of antenna gain.

Techniques to reduce the loss due to such nonconformity of polarization have conventionally been proposed. An example thereof, for a receiving antenna, is a technique to realize reception diversity, in which an antenna having vertical polarization as its main polarization, such as a whip antenna, and a receive-only built-in antenna having horizontally

polarized wave components, such as an inverted F antenna, are switched with each other.

Fig. 10 shows a configuration for the reception diversity in conventional portable radio equipment. Referring to Fig. 10, a transmitting/receiving antenna 21 and a built-in antenna 22 having main polarization different in direction from that of transmitting/receiving antenna 21 are provided. Transmitting/receiving antenna 21 and built-in antenna 22 are switched using a changeover switch 23, and either transmitting/receiving antenna 21 or built-in antenna 22 is connected via changeover switch 23 to a radio unit 24.

Assume that transmitting/receiving antenna 21 and built-in antenna 22 are receiving waves from the base station. As these two antennas are placed a prescribed distance apart from each other and have main polarization of different directions, the reception characteristics of these antennas change due to fading and others over time, with a prescribed correlation. In radio unit 24, control is performed to switch changeover switch 23 to either transmitting/receiving antenna 21 or built-in antenna 22 that exhibits a better reception characteristic during a certain period of time. Such control guarantees a more stable reception characteristic.

In the configuration shown in Fig. 10, if an inverted F antenna is employed as the receive-only antenna, it is difficult to provide a sufficiently large bottom board on the portable radio equipment. Thus, in the radiation pattern of the inverted F antenna, radiation from the longitudinal direction of the metal portion of the cabinet becomes dominant. As a result, the directivity and the direction of main polarization of the inverted F antenna come to approximate to those of the whip antenna, so that it becomes difficult to ensure adequate correlation of polarization between the antennas. In order to solve such a problem, one technique employs a microstrip antenna or a circularly polarized wave receiving antenna as the built-in antenna to increase the recognition level of cross polarization with the whip antenna.

Fig. 11 shows a built-in antenna for reception diversity of portable radio equipment disclosed, for example, in Japanese Patent Laying-Open

No. 6-338816. Referring to Fig. 11, an external antenna 31 and a built-in antenna 32 formed of one-side short-circuited type microstrip that is different in direction of main polarization and directivity from the external antenna 31 are built in a cabinet 33 of portable radio equipment. Since the direction of main polarization and directivity of external antenna 31 are different from those of built-in antenna 32, it becomes possible to increase the coefficient of correlation between the antennas, so that effective diversity is enabled.

Fig. 12 shows an example to improve the reception characteristic of portable radio equipment disclosed, for example, in Japanese Patent Laying-Open No. 6-188801. Referring to Fig. 12, an antenna 41 for linear polarization for use in receiving the linear polarization and an antenna 42 for circular polarization for use in receiving the circular polarization are provided. At the time of reception, antenna 42 for circular polarization waits for radio waves. When a detecting circuit 42 detects reception of desired radio waves, a controller 46 controls a changeover switch 43 to switch the reception antenna from antenna 42 for circular polarization to antenna 41 for linear polarization for use in transmission/reception. In this configuration, antenna 42 for circular polarization is used when receiving the radio waves. Thus, regardless of the direction in which the terminal is directed, degradation of antenna gain due to nonconformity of polarization can be decreased.

The examples described above are directed to improve the reception diversity characteristics. They do not attempt to decrease the loss due to nonconformity of polarization to improve the transmission characteristics of the portable radio equipment. To improve the transmission/reception characteristics by decreasing such loss due to nonconformity of polarization, the antenna may be mechanically inclined with respect to the cabinet.

Fig. 13 shows such an example disclosed in Japanese Patent Laying-Open No. 8-274525. Radio waves are fed from a metal cabinet 52 covered with a resin cabinet 51 through a coaxial line 53 to an antenna 54. An outer sheath of the upper portion of coaxial line 53 is connected with a cylindrical choke 54 having an electrical length of $\lambda/4$, so that, together

with antenna 55, the performance equivalent to that of a $\lambda/2$ dipole antenna can be obtained. At this time, the antenna is held in an erect position by means of a rotatable joint 56 regardless of the attitude of the portable radio equipment, and accordingly, the gain degradation of the transmission/reception characteristics due to nonconformity of polarization with the base station can be reduced.

Figs. 14A and 14B show an antenna 62 disclosed in Japanese Patent Laying-Open No. 6-268547, which is provided with a joint 63 so that, when antenna 62 is pulled out from a cabinet 61 of portable radio equipment, it is made perpendicular to the land surface. Thus, the gain degradation of the transmission/reception characteristics due to nonconformity of polarization with the base station is decreased.

These antennas, however, require structures for mechanical inclination thereof. In addition, a user of the portable radio equipment needs to adjust the angle of the antenna. Since the angle to which the antenna can be inclined is limited to a certain extent, the antenna may become a nuisance to the user when calling.

There is another way to switch the polarization by switching short-circuited points according to the attitude of the portable radio equipment. Fig. 15 shows an antenna portion of the configuration disclosed in Japanese Patent Laying-Open No. 2-94713. Referring to Fig. 15, a plate antenna 72 is provided on the bottom board 71, and radio waves are fed from an antenna feed point 73 to this plate antenna 72. Plate antenna 72 is placed on bottom board 71 by means of a short-circuited point 74 and short-circuited points 75 and 76 with changeover switches. Thus, even in a single antenna, changeover switches of short-circuited points 75 and 76 can be switched to change the direction of main polarization of the antenna, so that the gain deterioration due to nonconformity of polarization can be decreased.

This method has an advantage that polarization can be switched in one antenna. However, it has a disadvantage, as in the case of the inverted F antenna described above, that the bottom board of an adequate size cannot be ensured on the portable radio equipment, and thus, a

sufficient recognition level of cross polarization cannot be obtained. In addition, it is difficult to direct the main polarization in a direction orthogonal to the plate antenna that is shown as the Z direction in Fig. 15.

The transmitting/receiving waves from an antenna of portable radio equipment that is placed or held in any direction are likely to diverge in direction of main polarization from that of the antenna at the base station whose main polarization is vertical to the land surface, thereby causing loss. When a simple linear antenna is being utilized, the antenna needs to be inclined to realize the vertical polarization. This requires a certain mechanical structure, and further, the inclined antenna may cause discomfort of a user while he/she calls. Further, in the case where the direction of main polarization of one plate antenna is switched by switching short-circuited points, it is difficult to achieve a sufficient recognition level of cross polarization. There also exists a certain direction in which the main polarization cannot be directed with ease.

Disclosure of the Invention

Based on the foregoing, a primary object of the present invention is to provide portable radio equipment that can be fitted to plane of polarization of waves transmitted to or received from a base station, and that can electrically reduce loss due to nonconformity of polarization regardless of the direction in which the portable radio equipment is placed or held.

The present invention is directed to portable radio equipment provided with a radio unit formed of a transmitting/receiving circuit within a cabinet. It includes at least two transmitting/receiving antennas different in direction of main polarization from each other, and a power distributor that couples the respective antennas to the radio unit to cause the at least two transmitting/receiving antennas to operate simultaneously and that weights distribution amounts of power being dealt by the respective antennas.

Preferably, the portable radio equipment is further provided with a tilt detector for detection of a tilt angle of the cabinet, and a control circuit

for controlling, based on the detected tilt angle, power distribution by the power distributor so as to optimize transmission/reception of the at least two transmitting/receiving antennas.

Still preferably, the portable radio equipment is further provided with a reception strength detector for detection of received field strength of each of the at least two transmitting/receiving antennas, a comparator for comparison of the detected received field strength with the weighting of the antenna given by the power distributor, and a control circuit for controlling, based on the comparison output of the comparator, the weighting of the power distributor so as to optimize a ratio of the power being fed to the respective antennas.

The power distributor includes an impedance transformation circuit that controls impedance of the at least two transmitting/receiving antennas to change the weighting of the distribution ratio of the power being fed to the respective antennas, and an impedance adjustment circuit that adjusts total composite impedance of the at least two transmitting/receiving antennas and the radio unit.

The impedance transformation circuit and the impedance adjustment circuit are formed of variable capacitance diodes.

Preferably, the at least two transmitting/receiving antennas are placed in directions orthogonal to each other.

Still preferably, one of the at least two transmitting/receiving antennas is a whip antenna, and the rest of the antennas includes a meander antenna that is folded to meander so as to reduce the total length.

Brief Description of the Drawings

Fig. 1 is a diagram showing a schematic view of portable radio equipment according to a first embodiment of the present invention.

Fig. 2 is a block diagram of the portable radio equipment according to the first embodiment of the present invention.

Fig. 3 is a diagram showing specific examples of the impedance transformation circuits and the composite impedance matching circuit shown in Fig. 2.

Fig. 4 is a diagram showing a schematic view of portable radio equipment according to a second embodiment of the present invention.

Fig. 5 is a block diagram of the portable radio equipment according to the second embodiment of the present invention.

Fig. 6 is a diagram showing a schematic view of portable radio equipment according to a third embodiment of the present invention.

Fig. 7 is a diagram showing a schematic view of portable radio equipment according to a fourth embodiment of the present invention.

Fig. 8 is a block diagram of the portable radio equipment according to a fifth embodiment of the present invention.

Fig. 9 is a diagram showing exemplary details of loss of gain averaged through the horizontal plane during a call of portable radio equipment.

Fig. 10 is a schematic block diagram of conventional portable radio equipment employing a changeover reception diversity method.

Fig. 11 is a diagram showing a schematic view of conventional portable radio equipment employing the changeover reception diversity method to reduce loss due to nonconformity of polarization.

Fig. 12 is a block diagram of conventional portable radio equipment.

Fig. 13 is a diagram showing a schematic view of conventional portable radio equipment having an antenna mechanically inclined to reduce loss due to mismatch of polarization.

Figs. 14A and 14B are diagrams illustrating a conventional example to reduce the loss due to nonconformity of polarization by mechanically inclining the antenna.

Fig. 15 is a diagram illustrating a conventional example to improve transmission/reception characteristics in a single antenna by switching the direction of main polarization.

Best Modes for Carrying Out the Invention

Fig. 1 schematically shows portable radio equipment of the first embodiment of the present invention. Fig. 2 is a block diagram thereof.

Referring to Fig. 1, transmitting/receiving antennas 1 and 2,

different in direction of main polarization from each other, are attached to a cabinet 3 of the portable radio equipment. Transmitting/receiving antennas 1 and 2 are placed orthogonal to each other. As the transmitting/receiving antenna 1, a whip antenna is employed, which is pulled out upwards from cabinet 3. Transmitting/receiving antenna 2 is contained within cabinet 3 to extend in a horizontal direction. Since the directions of the electric fields transmitted/received through transmitting/receiving antennas 1 and 2 are orthogonal to each other, antenna coupling can be made small. The coefficient of correlation between these antennas can be made large, so that the recognition level of cross polarization can also be increased.

As shown in Fig. 2, transmitting/receiving antennas 1 and 2 are each connected directly to a variable power distributor 5 being connected to a radio unit 4. Variable power distributor 5 is formed of impedance transformation circuits 6 and 7 that are connected to transmitting/receiving antennas 1 and 2, respectively, and a composite impedance matching circuit 8. Impedance transformation circuits 6 and 7 are used to change the weighting of a distribution ratio of the power being fed to transmitting/receiving antennas 1 and 2. Composite impedance matching circuit 8 is used to adjust the total composite impedance of two transmitting/receiving antennas 1, 2 and radio unit 4.

A tilt angle detector 9, such as a gravity direction sensor, is further provided for detection of the tilt angle of cabinet 3. The detected output of this tilt angle detector 9 is supplied to a control unit 10. Based on the detected output of tilt angle detector 9, control circuit 10 controls impedance transformation circuits 6, 7 within variable power distributor 5, and changes the weighting of the distribution ratio of the power to be fed to transmitting/receiving antennas 1 and 2. Control circuit 10 also controls composite impedance matching circuit 8 at the same time, so that the composite impedance of impedance transformation circuits 6, 7 is matched to characteristic impedance to radio unit 4 seen from the antennas.

Impedance transformation circuits 6, 7 and composite impedance matching circuit 8 are formed of variable capacitance diodes C1-C9, as

shown in Fig. 3. More specifically, impedance transformation circuit 6 is formed with variable capacitance diodes C1 and C2 serially connected with each other, and another variable capacitance diode C3 that is connected between a connect point of variable capacitance diodes C1, C2 and a ground node. Similarly, impedance transformation circuit 7 is formed with variable capacitance diodes C4 and C5 that are serially connected with each other, and another variable capacitance diode C6 that is connected between a connect point of variable capacitance diodes C4, C5 and a ground node. Composite impedance matching circuit 8 is formed of variable capacitance diodes C7 and C8 that are serially connected with each other, and another variable capacitance diode C9 that is connected between a connect point of variable capacitance diodes C7, C8 and a ground node.

These variable capacitance diodes C1-C9 are provided with a prescribed level of voltage as a control signal from control unit 10. The capacitance is altered according to this voltage, so that the impedance is changed.

As described above, according to the present embodiment, transmitting/receiving antennas 1 and 2 are placed orthogonal to each other. Thus, the antenna coupling can be made small, and the coefficient of correlation between transmitting/receiving antennas 1 and 2 can be made large. Accordingly, the recognition level of cross polarization can be increased.

Fig. 4 schematically shows portable radio equipment of the second embodiment of the present invention. Fig. 5 is a block diagram thereof.

In the first embodiment shown in Figs. 1 and 2, first and second transmitting/receiving antennas 1 and 2 have been employed. In such a case, it is difficult to direct the main polarization in a direction (Y direction in Fig. 1) orthogonal to the electric fields of these transmitting/receiving antennas 1 and 2.

Thus, as shown in Fig. 4, three transmitting/receiving antennas 1, 2 and 11 are placed orthogonal to each other. By placing the respective antennas 1, 2 and 11 in a direction orthogonal to the electric fields being transmitted/received through the antennas, it is possible to control such

that the composed plane of polarization of the three antennas has vertical polarization with respect to the land surface, regardless of the direction in which the portable terminal is placed.

Corresponding to additionally provided transmitting/receiving antenna 11, an additional impedance transformation circuit 12 is provided within variable power distributor 5. Control unit 10 controls impedance transformation circuits 6, 7 and 12, as in the first embodiment, to change the weighting of a distribution ratio of the power being fed to the respective antennas. Composite impedance matching circuit 8 adjusts the total composite impedance of these three transmitting/receiving antennas 1, 2 and 11 and radio unit 4.

Thus, by providing three antennas 1, 2 and 11, the composed plane of polarization of the three antennas can be controlled to have vertical polarization with respect to the land surface regardless of the direction in which the portable terminal is placed.

Figs. 6 and 7 schematically show the third and fourth embodiments of the present invention, respectively.

The second embodiment shown in Fig. 4 is increased in the outside dimension, as it is provided with three transmitting/receiving antennas 1, 2 and 11. Thus, in Fig. 6, other than transmitting/receiving antenna 1 formed of a whip antenna, two transmitting/receiving antennas 2 and 11 are each formed of a meander type antenna that is folded to reduce the total length, or of a helical type antenna not shown.

Further, if the feed points of respective transmitting/receiving antennas 1, 2 and 11 are placed close to each other, as shown in Fig. 7, the antenna coupling can be made smaller, and therefore, the recognition level of cross polarization can further be improved.

Fig. 8 is a block diagram of portable radio equipment according to the fifth embodiment of the present invention.

In the embodiments shown in Figs. 2 and 5, tilt angle detector 9 has been provided, and the distribution ratio of power being fed to the respective antennas has been controlled based on the detected tilt angle. In the embodiment shown in Fig. 8, the distribution ratio of power being

fed to the respective antennas is calculated based on their reception levels. To that end, transmitting/receiving antennas 1 and 2 are connected to field strength detectors 12 and 13, respectively, and the received field strengths of the antennas are detected. The detected outputs of reception field strength detectors 12, 13 are supplied to an analog comparator 14. Analog comparator 14 has also been provided with weighting of the antennas from power distributor 5. Analog comparator 14 compares the magnitudes of the received field strengths and the weighting of the antennas, and determines which antenna is more effective in reception. The determined result is output to control unit 10 for feedback to the control of variable power distributor 5 in a next control time, so that the distribution amount of power to the antenna performing effective reception is increased. Repeating such control makes it possible to optimize the ratio of power being fed to respective antennas. In other words, the antenna efficiently performing reception is determined as an antenna having vertical polarization with respect to the land surface in its current position and state. The transmission/reception of the antennas is thus controlled.

As explained above, according to the present invention, at least two transmitting/receiving antennas are coupled to a radio unit so that they operate at the same time, and the weighting of distribution amount of power being dealt by each antenna is changed, so that the direction of the composed main polarization of the antennas can be matched to the plane of polarization of the waves transmitted to or received from the base station. Accordingly, it is possible to improve antenna gain by electrically decreasing loss due to nonconformity of polarization, regardless of the direction in which the portable radio equipment is placed or held.

The embodiments of the present invention have been described above in detail with reference to the drawings. However, the present invention is not limited to any of the embodiments, and many kinds of variations and modifications are allowed within the scope of the spirit of the present invention. The scope of the present invention is indicated by the scope of the claims as attached.

CLAIMS

1. Portable radio equipment provided with a radio unit (4) formed of a transmitting/receiving circuit within a cabinet, comprising:

at least two transmitting/receiving antennas (1, 2, 11) different in direction of main polarization from each other; and

a power distributor (5) coupling each said antenna to said radio unit such that said at least two transmitting/receiving antennas operate simultaneously and weighting distribution amounts of power being dealt by the respective antennas.

2. The portable radio equipment according to claim 1, further comprising:

a tilt detector (9) detecting a tilt angle of said cabinet; and

a control circuit (10) controlling power distribution by said power distributor based on the tilt angle detected by said tilt detector, such that said at least two transmitting/receiving antennas realize optimum transmission/reception.

3. The portable radio equipment according to claim 2, wherein said power distributor includes

an impedance transformation circuit (6, 7, 12) controlling impedance of said at least two transmitting/receiving antennas to change weighting of a distribution ratio of power being fed to the respective antennas, and

an impedance adjustment circuit (8) adjusting total composite impedance of said at least two transmitting/receiving antennas and said radio unit.

4. The portable radio equipment according to claim 3, wherein said impedance transformation circuit and said impedance adjustment circuit include variable capacitance diodes (C1-C9).

5. The portable radio equipment according to claim 1, further

comprising:

a reception strength detector (12, 13) detecting received field strength of each of said at least two transmitting/receiving antennas;

a comparator (14) comparing the received field strength detected by said reception strength detector with the weighting of the antenna given by said power distributor; and

a control circuit (10) controlling the weighting by said power distributor based on the comparison output of said comparator, to optimize a ratio of the power being fed to the respective antennas.

6. The portable radio equipment according to claim 4, wherein said power distributor includes

an impedance transformation circuit (6, 7, 11) controlling impedance of said at least two transmitting/receiving antennas to change the weighting of a distribution ratio of the power being fed to the respective antennas, and

an impedance adjustment circuit (8) adjusting total composite impedance of said at least two transmitting/receiving antennas and said radio unit.

7. The portable radio equipment according to claim 6, wherein said impedance transformation circuit and said impedance adjustment circuit include variable capacitance diodes (C1-C9).

8. The portable radio equipment according to claim 1, wherein said at least two transmitting/receiving antennas are placed orthogonal to each other.

9. The portable radio equipment according to claim 1, wherein one of said at least two transmitting/receiving antennas is a whip antenna, and the rest of said antennas includes a meander antenna that is folded to meander so as to reduce the total length.

## ABSTRACT

In a cabinet (3) of portable radio equipment, two transmitting/receiving antennas (1, 2) are placed orthogonal to each other. These transmitting/receiving antennas (1, 2) are connected via a power distributor (5) to a radio unit (4). A tilt angle detector (9) detects the tilt of the cabinet (3). A control circuit (10) controls impedance transformation circuits (6, 7), based on the detected tilt angle, to alter the weighting of a distribution ratio of power being fed to the respective antennas. A composite impedance adjustment circuit (8) adjusts total composite impedance of the transmitting/receiving antennas (1, 2) and the radio unit (4).

FIG. 1

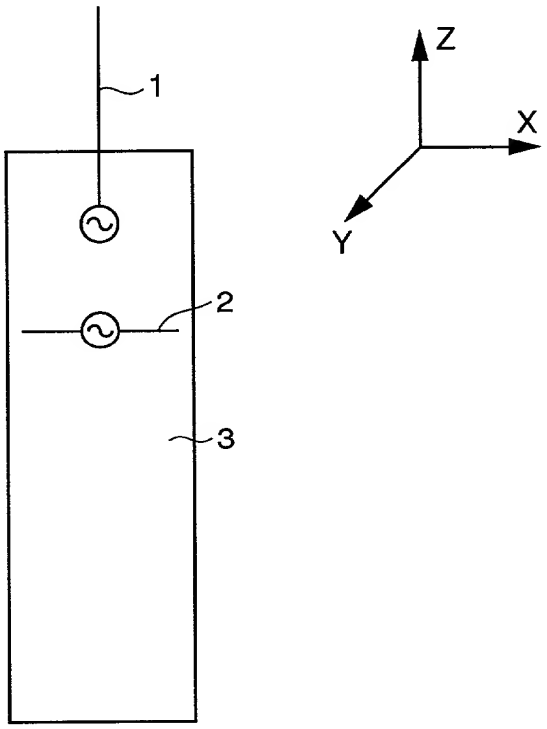



FIG. 2

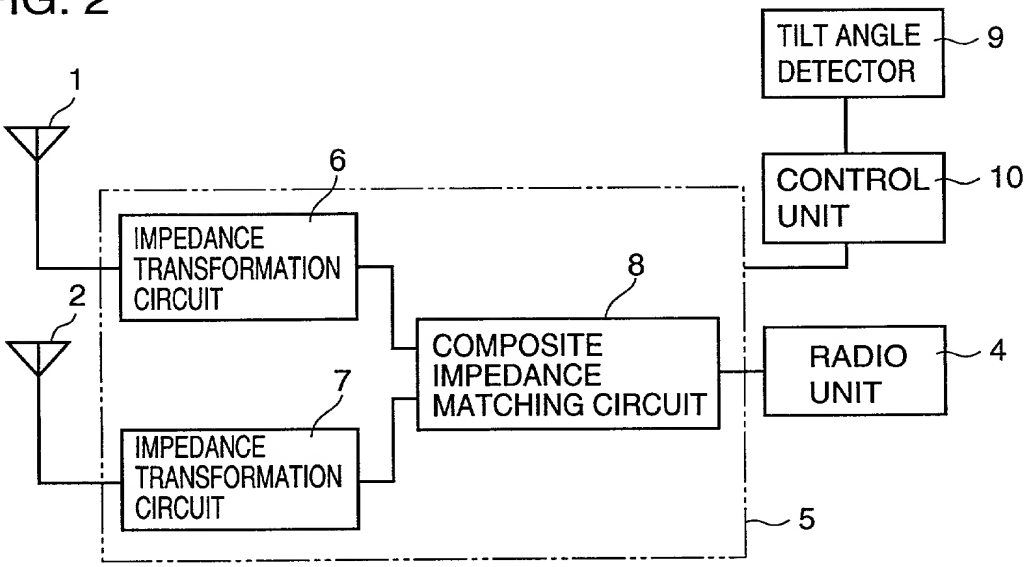


FIG. 3

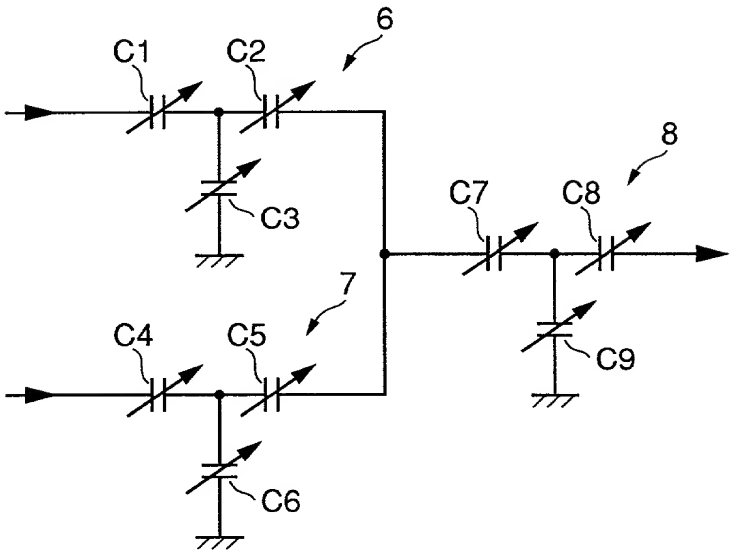



FIG. 4

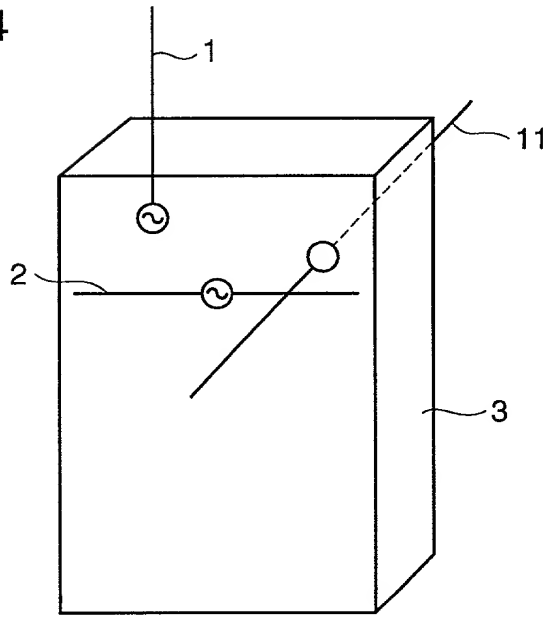


FIG. 5

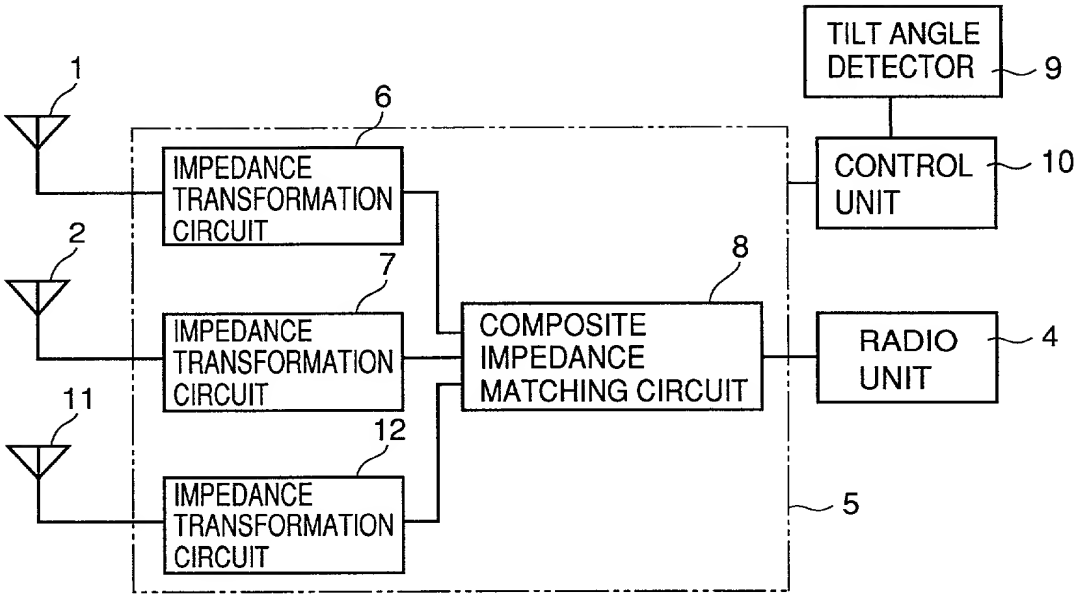

TILT ANGLE DETECTOR
9
1
6
IMPEDANCE TRANSFORMATION CIRCUIT
CONTROL UNIT
10
2
8
7
IMPEDANCE TRANSFORMATION CIRCUIT
COMPOSITE IMPEDANCE MATCHING CIRCUIT
RADIO UNIT
4
11
12
IMPEDANCE TRANSFORMATION CIRCUIT
5

FIG. 6

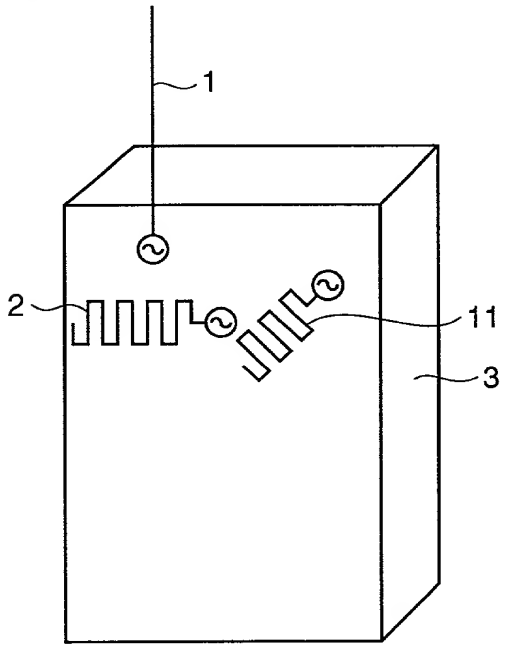

1
2
11
3

FIG. 7

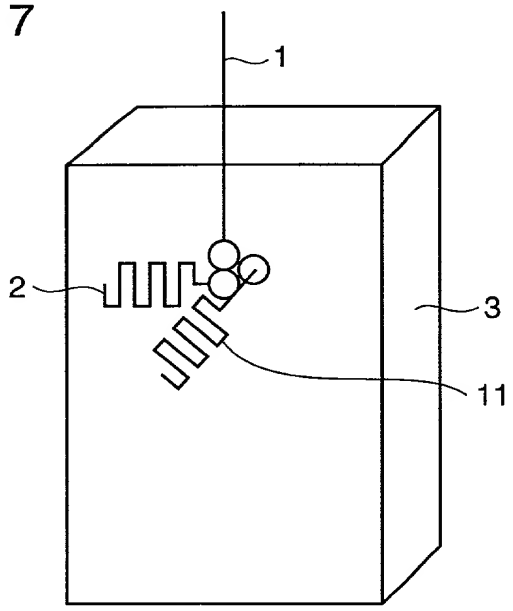



FIG. 8

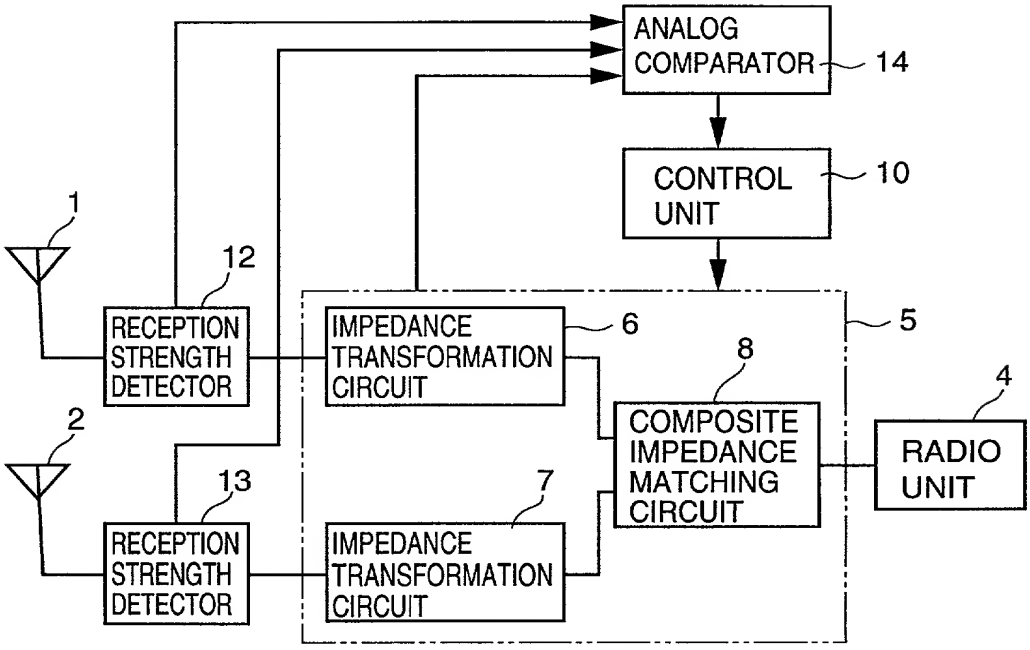


FIG. 9 PRIOR ART

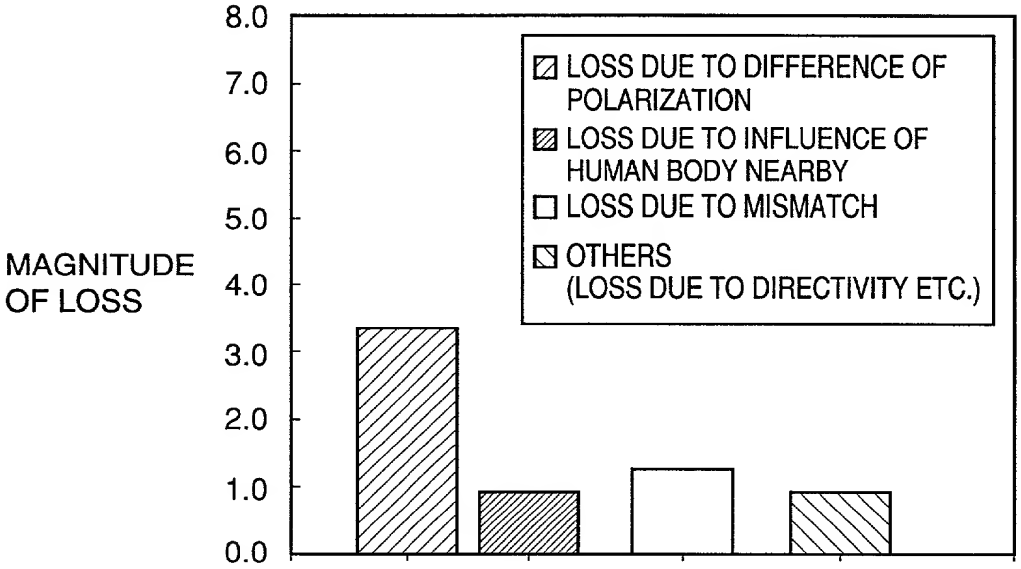



FIG. 10 PRIOR ART

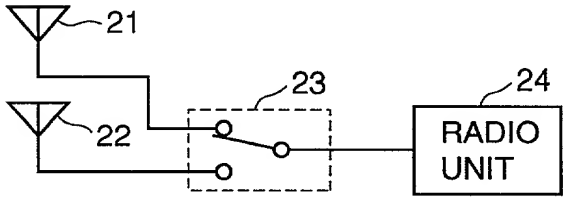


FIG. 11
PRIOR ART

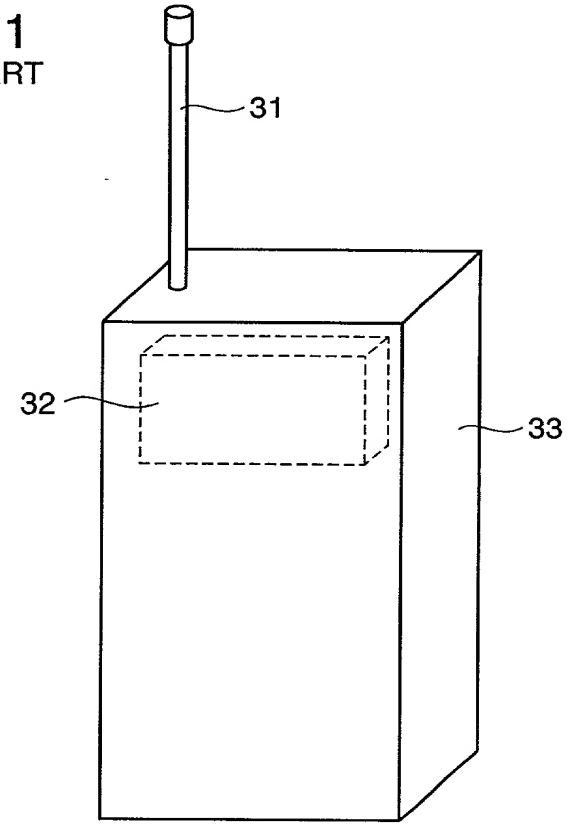



FIG. 12 PRIOR ART

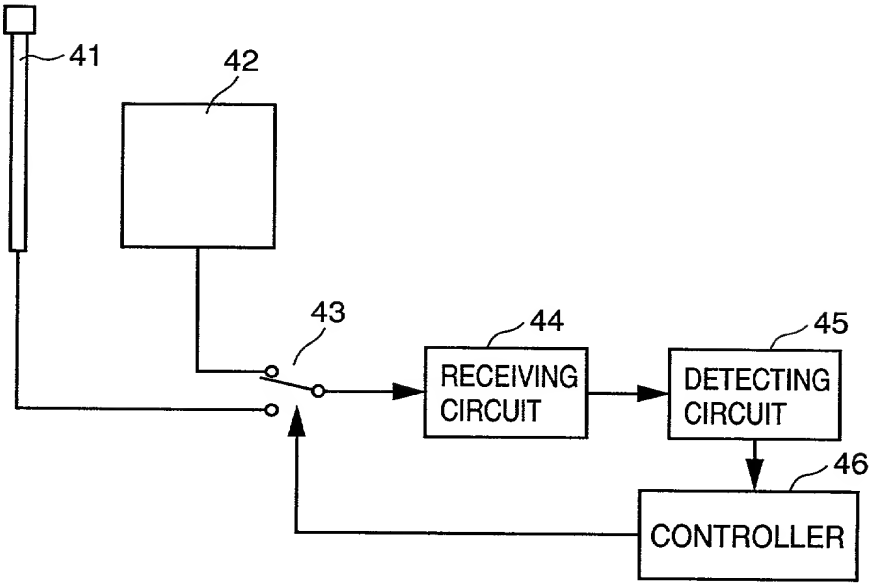


FIG. 13
PRIOR ART

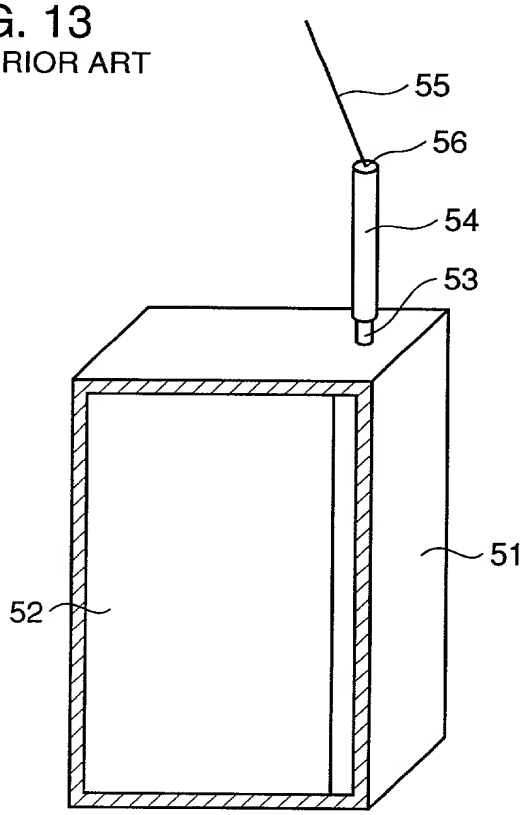



FIG. 14A
PRIOR ART

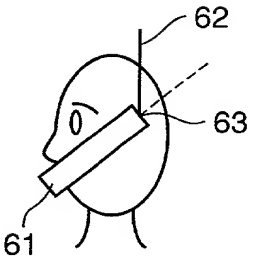



FIG. 14B
PRIOR ART

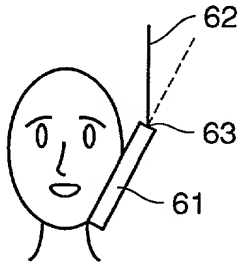
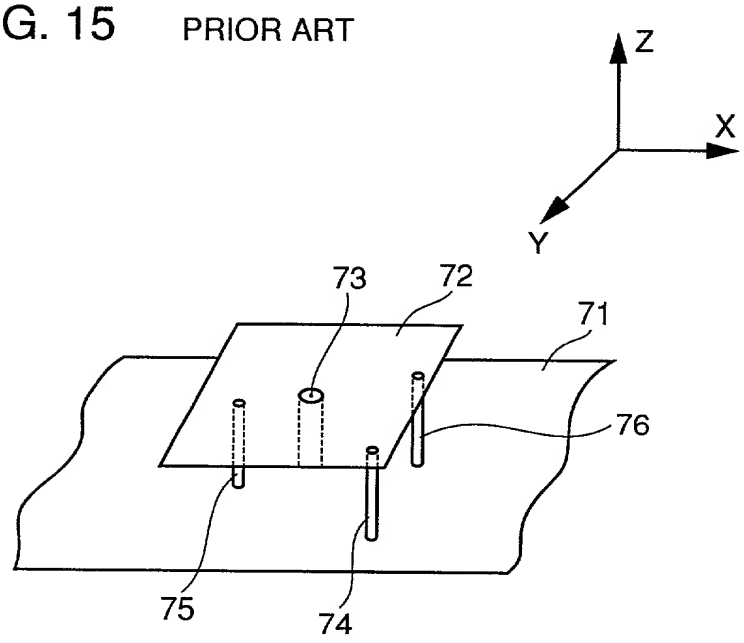


FIG. 15 PRIOR ART



# Declaration and Power of Attorney For Patent Application

## 特許出願宣言書

## Japanese Language Declaration

私は、下欄に氏名を記載した発明者として、以下のとおり宣言する：

As a below named inventor, I hereby declare that:

私の住所、郵便の宛先および国籍は、下欄に氏名に続いて記載したとおりであり、

My residence, post office address and citizenship are as stated below next to my name,

名称の発明に関し、請求の範囲に記載した特許を求める主題の本来の、最初にして唯一の発明者である（一人の氏名のみが下欄に記載されている場合）か、もしくは本来の、最初にして共同の発明者である（複数の氏名が下欄に記載されている場合）と信じ、

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

PORTABLE RADIO EQUIPMENT

その明細書を
(該当する方に印を付す)

the specification of which
(check one)

☐ ここに添付する。

☒ is attached hereto.

☐ _____ 日に出願番号

☒ was filed on January 11, 2000 as

第 _____ 号として提出し、

Application Serial No. PCT/JP00/00090

_____ 日に補正した。
(該当する場合)

and was amended on _____
(if applicable)

私は、前記のとおり補正した請求の範囲を含む前記明細書の内容を検討し、理解したことを陳述する。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37部第1章第56条（a）項に従い、本願の審査に所要の情報を開示すべき義務を有することを認める。

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

# Japanese Language Declaration

私は、合衆国法典第35部第119 条にもとづく下記の外国特許出願または発明者証出願の外国優先権利益を主張し、さらに優先権の主張に係わる基礎出願の出願日前の出願日を有する外国特許出願または発明者証出願を以下に明記する：

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior foreign applications
先の外国出願

| (Number)<br>(番　号) | (Country)<br>(国　名) | (Day/Month/Year Filed)<br>(出願の年月日) | Priority claimed<br>優先権の主張<br>☐ Yes あり | ☐ No なし |
|---|---|---|---|---|
| (Number)<br>(番　号) | (Country)<br>(国　名) | (Day/Month/Year Filed)<br>(出願の年月日) | ☐ Yes あり | ☐ No なし |
| (Number)<br>(番　号) | (Country)<br>(国　名) | (Day/Month/Year Filed)<br>(出願の年月日) | ☐ Yes あり | ☐ No なし |

私は、合衆国法典第35部第120 条にもとづく下記の合衆国特許出願の利益を主張し、本願の請求の範囲各項に記載の主題が合衆国法典第35部第112 条第１項に規定の態様で先の合衆国出願に開示されていない限度において、先の出願の出願日と本願の国内出願日またはＰＣＴ国際出願日の間に公表された連邦規則法典第37部第１章第56条（ａ）項に記載の所要の情報を開示すべき義務を有することを認める：

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

| (Application Serial No.)<br>(出願番号) | (Filing Date)<br>(出願日) | (現　況)<br>(特許済み、係属中、放棄済み) | (Status)<br>(patented, pending, abandoned) |
|---|---|---|---|
| (Application Serial No.)<br>(出願番号) | (Filing Date)<br>(出願日) | (現　況)<br>(特許済み、係属中、放棄済み) | (Status)<br>(patented, pending, abandoned) |

私は、ここに自己の知識にもとづいて行った陳述がすべて真実であり、自己の有する情報および信ずるところに従って行った陳述が真実であると信じ、さらに故意に虚偽の陳述等を行った場合、合衆国法典第18部第1001条により、罰金もしくは禁錮に処せられるか、またはこれらの刑が併科され、またかかる故意による虚偽の陳述が本願ないし本願に対して付与される特許の有効性を損うことがあることを認識して、以上の陳述を行ったことを宣言する。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

# Japanese Language Declaration

委任状：私は、下記発明者として、以下の代理人をここに選任し、本願の手続を遂行すること並びにこれに関する一切の行為を特許商標庁に対して行うことを委任する、
（代理人氏名および登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (*list name and registration number*)

(16)

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Bart G. Newland, Reg. No. 31,282
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Direct Telephone Calls to: (*name and telephone number*)

| | |
|---|---|
| 唯一のまたは第一の発明者の氏名 1-00 | Full name of sole or first inventor<br>Hideaki SHOJI |
| 同発明者の署名 日付 | Inventor's signature Date<br>Hideaki Shoji July 10, 2001 |
| 住所 | Residence<br>Hyogo, Japan JPX |
| 国籍 | Citizenship<br>Japanese |
| 郵便の宛先 | Post Office Address<br>c/o Mitsubishi Denki Kabushiki Kaisha, |
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| 第２の共同発明者の氏名（該当する場合） 2-00 | Full name of second joint inventor, if any<br>Yasuhito IMANISHI |
| 同第２発明者の署名 日付 | Second Inventor's signature Date<br>Yasuhito Imanishi July 10 2001 |
| 住所 | Residence<br>Hyogo, Japan JPX |
| 国籍 | Citizenship<br>Japanese |
| 郵便の宛先 | Post Office Address<br>c/o Mitsubishi Denki Kabushiki Kaisha, |
| | 2-3, Marunouchi 2-chome,<br>Chiyoda-ku, TOKYO 100-8310 JAPAN |

（第六またはそれ以降の共同発明者に対しても同様な情報および署名を提供すること。）

(Supply similar information and signature for third and subsequent joint inventors.)

# Japanese Language Declaration

| 第３の共同発明者の氏名(該当する場合) 3-00 | Full name of third joint inventor, if any<br>Toru FUKASAWA |
|---|---|
| 同第３共同発明者の署名　日付 | Third Inventor's signature　Date<br>Toru Fukasawa　July 10, 2001 |
| 住所 | Residence<br>Hyogo, Japan JPX |
| 国籍 | Citizenship<br>Japanese |
| 郵便の宛先 | Post Office Address<br>c/o Mitsubishi Denki Kabushiki Kaisha,<br>2-3, Marunouchi 2-chome,<br>Chiyoda-ku, TOKYO 100-8310 JAPAN |

| 第４の共同発明者の氏名(該当する場合) 4-00 | Full name of fourth joint inventor, if any<br>Hiroyuki OHMINE |
|---|---|
| 同第４共同発明者の署名　日付 | Fourth Inventor's signature　Date<br>Hiroyuki Ohmine　July 10, 2001 |
| 住所 | Residence<br>Hyogo, Japan |
| 国籍 | Citizenship<br>Japanese |
| 郵便の宛先 | Post Office Address<br>c/o Mitsubishi Denki Kabushiki Kaisha,<br>2-3, Marunouchi 2-chome,<br>Chiyoda-ku, TOKYO 100-8310 JAPAN |

| 第５の共同発明者の氏名(該当する場合) | Full name of fifth joint inventor, if any |
|---|---|
| 同第５共同発明者の署名　日付 | Fifth Inventor's signature　Date |
| 住所 | Residence |
| 国籍 | Citizenship |
| 郵便の宛先 | Post Office Address |
| | |

| 第６の共同発明者の氏名(該当する場合) | Full name of sixth joint inventor, if any |
|---|---|
| 同第６共同発明者の署名　日付 | Sixth Inventor's signature　Date |
| 住所 | Residence |
| 国籍 | Citizenship |
| 郵便の宛先 | Post Office Address |
| | |

(第７またはそれ以降の共同発明者に対しても同様な情報および署名を提供すること。)

(Supply similar information and signature for seventh and subsequent joint inventors.)